

INFORMAL LETTER PROGRESS REPORT TO NASA ON PROGRESS AT THE JICAMARCA
RADAR OBSERVATORY DURING THE PERIOD APRIL - JUNE, 1965

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INCOHERENT SCATTER

The last detailed account of progress on the measurement of ionospheric properties using incoherent backscatter was given in the paper, "Observations of the equatorial ionosphere using incoherent backscatter", by D. T. Farley, Jr., which was presented at the NATO Advanced Study Institute on Electron Density Profiles in the Ionosphere and Exosphere in Finse, Norway, during April, 1965. This paper was also submitted to NASA as a progress report covering the period January - March, 1965. During the period of the present report, two more sets of data, each covering a period of roughly 48 consecutive hours, were taken. The results obtained were comparable to those discussed in the above paper for the period 1 - 3 February, 1965.

With the increase in data output both from the Jicamarca incoherent scattering studies and from satellite experiments, more comparisons of the respective results are becoming possible. A considerable number of comparisons of topside electron density profiles obtained from the topside sounder satellite and from Jicamarca have been made. These cover an altitude range from about 300 kilometers to 1000 kilometers. The latest comparisons show very good agreement. There is still a slight discrepancy which apparently is caused by a small systematic error in the topside sounding measurement which is not yet understood. The profiles obtained by the topside sounder consistently show the peak of the F layer to be 10 or 20 kilometers too low in altitude. This error is revealed both by comparison with bottomside soundings and with profiles obtained from incoherent scatter. Hopefully, continued comparisons with the Jicamarca profiles will aid in discovering the source of the error.

The values of electron density and temperature obtained from Explorer XXII agree well, for the most part, with the Jicamarca results. It appears, however, that there is an appreciable discrepancy between the values of daytime electron temperature at 1000 kilometers obtained with the two techniques. The error most probably lies in the Jicamarca measurement.

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Only a small number of results are available from Jicamarca, and these are probably not very accurate at altitudes as great as 1000 kilometers.

In fact, one of the major preoccupations at Jicamarca during the last two months has been the improvement of the temperature and ion composition measurements. The latter quantities can be derived from the auto-correlation function or the power spectrum of the incoherently scattered signal. The latter is just the Fourier transform of the former, and at Jicamarca it turns out to be much more convenient to measure the auto-correlation function. Up to the present, this measurement has been plagued by small systematic variations in the transmitting and receiving equipment which distort the results. These distortions make interpretation of the results particularly difficult at high altitudes, where mixtures of ions are present. When all of the systematic errors have been eliminated, which should be in the near future, it will be possible to make quite accurate measurements of the electron and ion temperatures and the ionic composition to altitudes somewhat beyond 1000 km. When this information becomes available, it should greatly improve our understanding of the equatorial ionosphere. We will be able to study the dynamic behavior of the density, temperature, and composition simultaneously. Because of the importance of this measurement, a large amount of time has been devoted to it in recent months, and this has resulted in a somewhat reduced rate of data taking.

STUDIES OF SCATTERING BY PLASMA WAVE IRREGULARITIES

The principal activity in this portion of the work has been the study of field-aligned irregularities in the equatorial electrojet. Recently NASA launched a series of rockets through the equatorial electrojet from the aircraft carrier Croatan off the coast of Peru. We obtained radar echoes from the plasma wave irregularities in the electrojet at the time of the rocket launchings. These records are now being analyzed. The results, when combined with those from the rocket experiments, should substantially improve our understanding of the irregularities.

DAYTIME SCINTILLATION

The scintillation of radio signals from discrete extraterrestrial

sources is of course a familiar subject. In previous publications we have reported observation of the very intense night time scintillations which occur at the magnetic equator in conjunction with equatorial spread-F.

Radio star observations have been made at Jicamarca sporadically ever since the antenna was first completed. It has almost always been observed that the intense radio source Hydra-A scintillates, even during the daylight hours. Brief measurements made during 1962 showed that the rate of the daytime scintillations is from 10 to 20 per second, or nearly a factor of ten faster than normally observed at other latitudes. The daytime scintillations were difficult to explain on the basis of known scintillation phenomena at other latitudes, and the subject was dropped temporarily in favor of more pressing matters concerning the incoherent scatter experiment.

Recently observations have been reported from Cambridge and from Arecibo showing that signals from radio sources of less than about 2 seconds of arc diameter scintillate at 200 Mc/s due to irregularities in the interplanetary medium. This has been deduced because the diffraction phenomenon is such that ionospheric irregularities should cause scintillation of stars up to more than 10 minutes of arc in diameter. A consistent argument has been offered to show that the observed scintillations could be caused by irregularities of 250 Km or about 1 Fresnel zone in extent, at a distance of 1 A.U., and drifting across the propagation path at the solar wind velocity of about 300 Km/sec.

It appeared possible that the daytime Hydra-A scintillations might be caused by large irregularities immersed in the boundary region of the magnetopause. If there were irregularities in that region with a scale size of about 20 Km, density fluctuations of about 10 per cc, and if one assumed a magnetopause about 10,000 Km thick, scintillations similar to those observed at Jicamarca with Hydra-A would be produced. An experiment was conducted during the month of June to check this possibility.

If the Hydra-A scintillations were caused by 20 Km irregularities, then their drift speed should be on the order of 10 Km/sec. If they were caused by ionospheric irregularities, those irregularities would be

about 1 Km in extent. If observations were made with spaced receiving stations separated by some substantial fraction of 1 Km, ionospheric irregularities should produce a measurable time delay separating the scintillations observed at the two stations. No significant time delay should appear at this distance for magnetospheric scintillations.

Phase switched interferometers were installed at the corners of the main Jicamarca array with an east-west separation of about 400 meters. In each case two $1/64$ modules of the main array were used as the interferometer elements. Hydra-A scintillations were recorded on several days during the period 1600 to 1715 local time. Each of several cross correlation analyses of sections of the records obtained on the two interferometers showed maximum correlation of about 50 percent at a time delay of about 2 seconds. Autocorrelation analyses performed on the individual records showed $1/e$ correlation for time delays ranging from 1.5 to 5 seconds. On each day the intensity of scintillation varied from a large level ($\pm 20\%$ to $\pm 50\%$) early during the recording, to a very small level near the end of the pass of the star through the antenna pattern.

The delay associated with the cross correlation function indicates that the irregularities were traveling with a horizontal velocity of about 200 meters per second. The 50 percent maximum of the cross correlation suggests that the scale of the irregularities, corresponding to $1/e$ spatial autocorrelation, is about 500 meters. Both measurements indicate that the observed scintillations are of ionospheric origin. The period during which the observations were made - 1600 to 1715 local time - is the period during which the equatorial electrojet is dying away rapidly. Since the scintillations were also observed to be dying away during this period, we offer the conjecture that the scintillations are in fact being produced by irregularities in the E region and are generated by the equatorial electrojet. Since the scintillation process at E region heights and 50 Mc/s would favor irregularities having a scale of about 750 meters (1 Fresnel zone), the observed scale is in approximate agreement with this conjecture. In view of this result, it will be desirable to conduct observations of scintillating daytime signals from a beacon satellite in order to determine the height of the irregularities more precisely (by relating the velocity of the drifting irregularities to the

velocity of the satellite).

The Hydra-A scintillation observations do not preclude the possibility that irregularities at the magnetopause might cause observable scintillations. They do suggest that it will not be possible to make such observations at Jicamarca because any magnetopause effects would be masked by the ionospheric scintillation.

The scattered energy associated with the observed scintillations will be distributed over an angular spectrum of little more than 10 minutes of arc. If it can be assumed that the irregularities are magnetic field aligned, then this broadening should be greatest in the east-west direction. Since the main Jicamarca antenna beam is about 1.1 degree wide, we conclude that the effect of the scintillations on the incoherent scatter measurements must be negligible.